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Arsenic Emissions from the ASARCO Smelter
Tacoma, Washington

Presented by
Michael M. Johnston
Dana Davoli

US Environmental Protection Agency
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On July 11, 1983, the US Environmental Protection Agency (US EPA) proposed an arsenic NESHAP (National Emission Standard for Hazardous Air Pollutants) under Section 112 of the Clean Air Act. This NESHAP was proposed for three industrial categories, copper smelters processing high-arsenic feed ore, copper smelters processing low-arsenic feed ore, and glass manufacturing plants. EPA's approach in developing this NESHAP was to require at a minimum best available technology (BAT) for control of arsenic emissions at source categories estimated to cause a significant public health risk. More stringent controls could be required if necessary to prevent unreasonable health risks remaining after BAT (taking costs and technical feasibility into account).

The only facility in the first industrial category (high-arsenic copper smelters) is the ASARCO smelter in Tacoma, Washington. It was built in 1890 and operated as a lead smelter until ASARCO bought it in 1905 and converted it to a copper smelter. This copper smelter processes copper ores (many of which are from foreign sources) with an average arsenic content of 4% compared to the other copper smelters in the US which use feed ores with less than 0.6% arsenic.

EPA has estimated that current emissions of arsenic from this facility are about 311 tons per year - 165 tons per year from stack emissions and the rest from fugitive sources.* Proposed BAT, which is hooding over one of the processes at the plant to capture fugitive emissions, is projected to reduce arsenic emissions from 311 to 189 tons per year.

Several epidemiological studies done on workers, including those at the ASARCO facility, indicate that exposure to airborne arsenic causes respiratory cancer. Because it is a carcinogen, EPA has presumed that arsenic is a no-threshold pollutant and that effects may occur at any level of exposure. The risk assessment for residents living near the smelter was extrapolated from the cancer risks seen in the workplace at higher levels of arsenic exposure, using a linear model. Estimates of exposure in the population around the smelter were developed from population data and the projected ambient air concentrations calculated from dispersion modeling. It was estimated that in a population of 368,000 people living near the smelter the excess lung cancer cases expected to result from ASARCO emissions ranged from 1.1. to 17.4 per year before BAT is installed to 0.21 to 3.4 following BAT. Lifetime risks for the highest calculated level of exposure (30 ug/m^3) was 9/100 before controls and 2/100 after BAT. Because of the assumptions made (e.g., linear extrapolation model), these estimates are thought to be conservative and indicative of upper bound life-time cancer risks. There is also much uncertainty in these numbers because of the difficulty in obtaining fugitive source emission data and because many assumptions must be made in developing the risk assessments.

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* These estimates will likely be lowered based upon additional testing done at the facility during September and October.

Much attention has been focused upon the arsenic NESHAP for the Tacoma facility because the estimated residual health risks remaining after BAT are high relative to those estimated for other sources regulated by NESHAPs. Additionally, William Ruckelshaus, the Administrator of EPA, has decided to involve the public more in the risk management decisions made by EPA. The arsenic NESHAP is the first such regulation targeted for enhanced public involvement, with EPA's efforts directed thus far on the ASARCO facility. To involve the public, EPA has put much effort into press releases and other published material, attempting to explain technical information and the decision-making process in terms the public can understand. Three public workshops were conducted to present the data and answer the public's questions and numerous presentations were made before interested groups. Although it has been reported in the press that EPA has asked the citizens living around the smelter to "vote on the issue of health versus jobs", this is not the case. This decision will be made by the Administrator of EPA alone. The purpose of the workshops and other public programs is to provide as much information to the public as possible so that their comments will be made with the full knowledge of the technical and other issues upon which the regulatory decision will be made.

The proposed arsenic NESHAP deals with controls of current emissions of arsenic from the ASARCO smelter. However, potential problems also exist in the community surrounding the smelter as a result of historic emissions of arsenic. Deposition of arsenic has resulted in contamination of soils, household dusts, and vegetables, with the highest levels occurring closest to the smelter. For example, recent sampling of surface soil close to the facility has shown soil arsenic levels of several thousand parts per million (ppm) while garden soil (which is tilled and often mixed with non-soil nutrients) is at levels of several hundred ppm. The most recent analyses have shown that the average arsenic content of vegetables from these gardens is about 24 ppm, while maximum values of over 400 ppm have been found. Household dust has been shown to contain levels of arsenic as high as 4641 ppm. Analyses of urine samples from children living near the smelter also show that arsenic levels are significantly above normal. Average urinary arsenic levels have ranged from 20-300 ug/l (micrograms per liter) with maximum levels up to 890 ug/l. (Background levels for unexposed populations are usually less than 25 ug/l).

The flow diagram shown in Figure 1 illustrates the pathways and routes of exposure that may be responsible for the increased arsenic body burden in these children. In addition to inhalation of recently emitted arsenic, inhalation of resuspended soils and dusts are also possible. Contaminated soils and dusts are of particular concern for young children because they ingest small amounts in normal hand-to-mouth activity. It has been estimated that children with pica, an abnormal craving for dirt, can ingest several grams of soil a day. Studies around lead smelters have confirmed that this can be a significant exposure route for children. Finally, ingestion of contaminated vegetables and water are potential sources of arsenic, although studies thus far do not show problems with drinking water supplies in the smelter area.

While current arsenic emissions are to be controlled through the arsenic NESHAPs, the potential problems resulting from past emissions are being dealt with through EPA's Superfund program. The Washington Department of Ecology (WDOE) under a cooperative agreement with EPA, is the lead agency in these Superfund efforts and is working with EPA and the state and local health agencies to design the investigations discussed below.

The high urinary arsenic levels of children living near the smelter show that they are exposed to arsenic, but the pathways leading to this exposure are not clear. These pathways must be determined before decisions can be made about implementing remedial actions which will result in lowered urinary arsenic levels. For example if current emissions are a significant source, then controls on these emissions at the plant are appropriate. If resuspended soil is an important exposure source, it may be necessary to remove soil or cover it with sod or paving. The Superfund investigations are being designed to provide data on sources of exposure which will in turn be used to plan remedial measures.

Although several samplings of soils, vegetables and urine have been made in the past, much of this data may not reflect the current situation and was not collected in a way that answers the questions on exposure pathways. Therefore several types of additional studies have been proposed and are in the design stage, including an Exposure Assessment Study. (See Table 1 for examples).

The Exposure Assessment Study will be patterned after those already conducted around several lead sources in the US. It involves taking measurements of contaminants in various media (e.g., soil, dust) concurrently with measurements of body burden (urinary arsenic in this case). Multivarient statistical techniques will then be used to attempt to correlate excess urinary arsenic levels with contamination levels in the different media. Studies such as these can include measurements of contaminants in soils, house dusts, and vegetation. To obtain an estimate of the amount of contamination on children's hands, hand loading studies are done. This involves dipping children's hands into a dilute acidic solution (about the pH of vinegar) and analyzing the solution. The Center for Disease Control is now working with WDOE, EPA and the local health agencies to design and implement this Exposure Assessment for the ASARCO area.

The State health department is also assessing the need for further epidemiological studies. Two lung cancer mortality studies done in the Tacoma area did not demonstrate an increased risk for persons living near the smelter, however this effect is probably too small to study epidemiologically. Blood analyses and hearing tests on children attending the school near the smelter also appear normal.

As can be seen from this discussion, emissions of arsenic from the ASARCO smelter have resulted in potential problems due to air pollution as well as to contamination of other environmental media. This situation stresses the need for pollution control agencies to take a more integrated approach in dealing with toxicants.

Table 1

Examples of Planned Studies

Exposure Assessment Study - May include measurements of contaminants in soils, vegetables, household dusts and air concurrent with measurements of body burden levels (such as urinary and hand loadings). This is done for a sampling of residents in the affected areas. Multivariate statistical analysis is performed on the resulting data to delineate and quantify sources of exposure and to predict the effectiveness of different remedial actions (Already completed or in progress at smelters in Texas, Idaho and Montana).

Deposition Monitoring - Use of acid precipitation equipment to determine the level of current deposition of arsenic occurring near the smelter. Related to past vs. present smelter operation issues as well as potential remedial actions involving soil clean up.

Soils - Isopleth Study - Soil sampling of areas near the smelter to determine the geographic extent of the most contaminated areas and the areas that may require remedial action.

Drinking Water Survey - Sampling and analyses of well water cisterns and other drinking water supplies in areas of high arsenic in soil or air.

Soil Leaching Tests - Leaching tests on soils with high contamination levels to determine potential for environmental movement, especially to groundwater.

Source Apportionment Model - Uses chemical mass balance approaches to determine the contribution of specific emission points within a facility to ambient pollutant levels as well as the contribution of resuspended contaminated soils and dusts. Distinguishes between air contamination due to current vs. historical deposition.

Figure 1

Conceptual Framework for Arsenic Exposure

Sources

Tacoma Smelter
- Current Air Emissions
  - short term peaks (upsets)
  - average (annual)
- Historic Air Emissions

Other Anthropogenic Sources
Natural Background

→ Source Contributions (direct & indirect) →

Ambient Environment

Air
Soil
Vegetation
House Dust
Surface Water
Ground Water
etc.

Complex Environmental Recycling

→ Exposure Pathways →

Human Exposures

Inhalation
Ingestion
- foods
- drinking water
- pica

Dermal Absorption

→ Body Burden Measures →

Indices

As
- urine
- hair
- blood
- bone
- organs

Enzyme/Protein Levels

→ Significance/Health Risks →

Health Effects

Outcomes
- Mortality
- Morbidity

Risk Assessments
Epidemiological Studies